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Bulletin No. 103 - Milling Qualities of Meat

Robert Stewart

Joseph E. Greaves

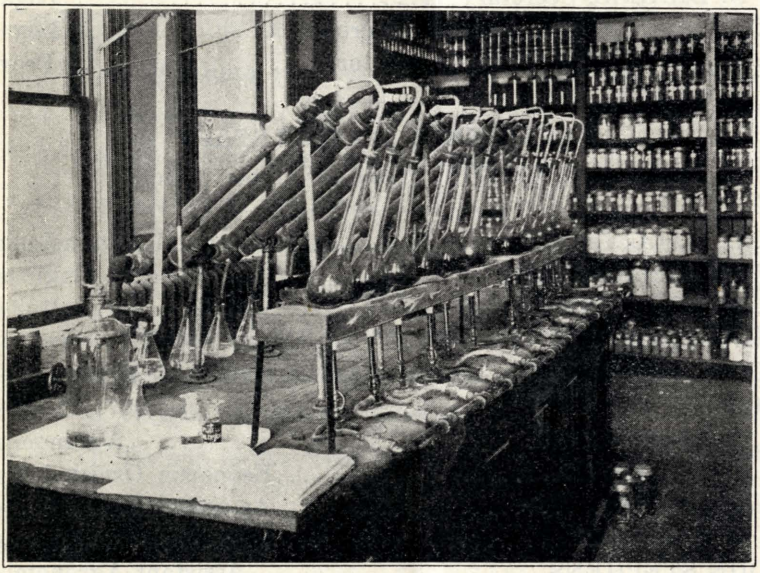
EXPERIMENT STATION

OF THE

AGRICULTURAL COLLEGE

OF UTAH

Bulletin No. 103



MILLING QUALITIES OF WHEAT

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The Milling Qualities of Wheat

Robert Stewart and Joseph E. Greaves.

A. INTRODUCTION.

Investigations regarding the chemical and milling characteristics of some of the various varieties of wheat grown in the State have been carried on since the season of 1904. This is, however, the first report of the investigations that has been published. The work was started with the hope of assisting in the determination of the varieties of wheat best adapted to the State. While, of course, the variety which does not yield well but which has excellent chemical and milling characteristics is not desirable, yet on the other hand, as has already been so often pointed out, neither is the variety desirable which yields well but has poor chemical and milling characteristics. The ideal which we must strive to obtain is the high yielding variety, having the best chemical and milling characteristics. Of course yield commands the first attention but it must not be forgotten that the wheat is to be converted into flour which must have the necessary strength to produce a good loaf of bread. Quality of product must be combined with high yielding properties in order that our farmers may command the best price for their product.

1. The Necessity of the Investigation.

The work reported in the following pages represents the analysis of ninety-one samples of wheat grown on our several experimental farms. Twenty-one samples were grown on the Greenville Farm under irrigated conditions, receiving varying amounts of irrigation water. The remainder of the samples were

grown under arid conditions on the experimental farms located in the following counties; Washington, Iron, San Juan, Sevier, Tooele, and Juab. The wheat grown on these farms includes all the more common varieties of wheat grown in Utah at the present time, and also a number of other promising varieties which have recently been introduced into the state. Richardson* has shown that wheat is one of the most susceptible to its environment, of all the grains. Jaffa** has shown that California flour is very much poorer in nitrogenous compounds than Eastern flour of the corresponding grade.

In view of the fact that the wheat industry of the State has received a new impetus during the last few years and that many new varieties have been and are being introduced into the State, it behooves us to determine how the various varieties of wheat grown in Utah under various conditions compare in their milling and chemical characteristics with the same wheat in other parts of the country. When one takes into consideration the above facts, it can readily be seen that any work, which is undertaken with a view of indicating some of the best varieties of wheat adaptable to this section of the country, is very desirable.

2. Description of Milling Apparatus.

The wheat was milled in one of the small experimental mills sold by the Allis-Chalmers Company of Milwaukee. The mill is shown in Plate 1. It is provided with two set of seven inch rollers,—one corrugated, the other smooth. The sifter, placed on a frame between the rollers, is provided with the requisite number of sieves. These sieves are covered with bolting silk, which is of the standard grades used in large flour mills. The mill is fitted with a feed adjustment so that the feeding can be nicely regulated. The products from the rollers are caught in drawers placed beneath the rollers; from these drawers it is transferred to the sifter. In order to facilitate this transfer without loss, a flat bottom scoop is used. The drawers are brushed with a three inch paint brush. This brush is also used in cleaning the

*Bulletin Nos. 1, 4, and 9, Bureau of Chemistry, U. S. Dept. of Agric.

**Annual Report California Experiment Station, 1893-94.

mill after the milling of each sample. In order to have something to receive the various products milled, and that it may be transfrred to the scale without loss, three pans were made. These were flat on the bottom and three sides while the fourth side was drawn out into a funnel.

The various milled products were weighed on a set of beam balances, which were sensitive, with the load used, to within five

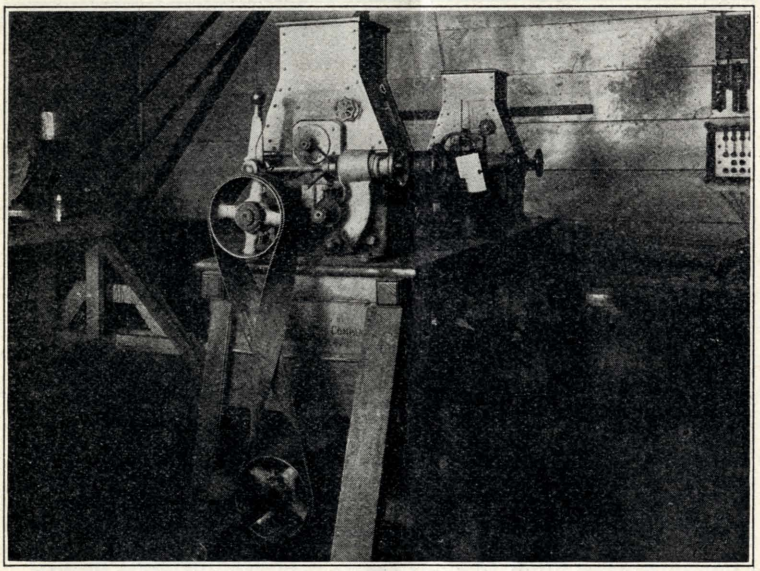

PLATE 1.

grams. These accessories are shown in Plate 2. The motive power for this reduction plant was furnished by a ten horse power electric motor. With the above named apparatus it is possible, with care, to mill a sample of wheat with very little loss. While the results obtained cannot be taken as absolute, they are comparative. The results may also show a greater amount of glutenin in the flour than would be shown if the wheat were milled more closely. E. Fleurent* found that the gluten contains a higher percentage of glutenin as the center of the grain is reached.

*Compt. Rend. Acad. Sci. Paris. 126, 1592-1596.

3. How the Wheat Was Milled.

The sample of wheat used in milling weighed about thirty pounds. Before milling, the wheat was carefully fanned. After being cleaned, it was run through the mill with the corrugated rollers, just close enough to mash the grain. The crushed product was then put into the sieves. The sieves were arranged in the following order; 1A uppermost, 2A next, and 3A on the bottom.

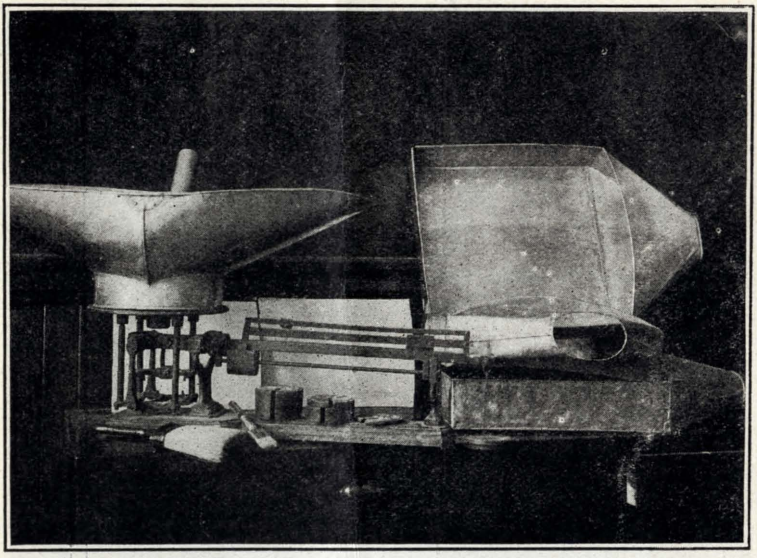

PLATE 2.

No. 3A was made of No. 68XX Shindler bolting silk. No. 2A was made of No. 30 gauze while No. 1A was made of No. 20 wire screen. After all the finer material was sieved out, that remaining on sieve 1A was again run through the corrugated rollers, the rollers being closer together; again sieved as before and that which now remained on sieve 1A was set aside and weighed as finished bran. The products from sieves 2A and 3A were then passed through the smooth rollers and again sieved. That which still remained on sieve 2A was mixed with that taken from 1A and the whole recorded as bran. That which remained on sieve 3A was weighed and recorded as shorts, while all that passed through 3A was recorded as flour. The flour we speak of in the succeeding

pages is, therefore, that part of the grain which, on being passed through the corrugated and smooth rollers, will pass through number 68XX Shindler bolting silk.

4. Methods of Analysis.

The methods of analysis used were, with very slight modification, those used by Snyder* in his work with flour. They were as follows:

The Protein. The total protein was obtained by determining the total nitrogen in the grain and multiplying this by 5.7 for protein. Inasmuch as many reports give the total protein of the milling products of wheat as N x 6.25 this calculation has been made and the results inserted for comparison.

Gliadin Determination. Four grams of flour were weighed out into a flask and 100c.c. of 70 per cent. alcohol was added and let stand with occasional shaking for twenty hours; the insoluble portion was now separated by filtration and 25c.c. of the filtrate was measured into a Kjeldahl flask; 3c.c. of sulphuric acid were added, the alcohol evaporated, the remaining 17c.c. of sulphuric added, and the nitrogen determined as in the Kjeldahl method for nitrogen; the nitrogen obtained multiplied by 5.7 gave the gliadin content.

Gluten Determinations. Ten grams of flour were weighed in a tarred evaporating dish and transferred into a dish of convenient size: 7 or 8 c.c. of water, having a temperature below 15 degrees were added and the mass was worked into a ball with a spatula, care being taken that none of the material adhered to the dish. The ball of dough was allowed to stand for one hour, then washed in a stream of cold tap water until the starch and soluble matter was removed, as indicated by testing with **a solution of iodine.** The dough was kneaded in the hand without the use of a cloth during this operation. The ball of gluten thus obtained was placed in cold water and allowed to remain for one hour. It was then removed and pressed as dry as possible between the hands,

*University of Minnesota Bull. No. 63.

rolled into a ball, placed upon a piece of heavy paper and weighed. The weight thus obtained being recorded as moist gluten. The moist ball was dried in steam bath for 24 hours, weighed and recorded as dry gluten.

***Acidity of Flour.** For the determination of the acidity of flour, 20 grams of flour were brought in contact with 200 c.c. of water, thoroughly shaken and after two hours, filtered. 50 c.c. of this filtrate was titrated against N/20 solution of sodium hydroxide, using phenolphthalein as an indicator.

Glutenin. The glutenin was obtained by difference. Snyder says that for all practical purposes the total protein minus the gliadin will give the approximate value for glutenin. Our glutenin data was obtained in this way. The column headed "Percentage of protein in the form of gliadin" is self explanatory. This column contains valuable and important data.

Ash of Flour. The ash was obtained by heating about 5 grams of the flour to dull redness, until a white ash was obtained. The ash was obtained much more readily by heating for some time at a dull red heat than by heating the same length of time at a much higher heat.

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*The report of the V. Internatonaler Kongress fur Angewandte Chemie P. 705.

B. EXPERIMENTAL PART.

1. Yield of Grain.

The question regarding the best yielding variety of the various kinds of wheat grown under arid conditions, which are under consideration has been discussed quite fully by Prof. Jardine in Bulletin No. 100 of this Station. For complete information reference should be made to that publication but the following paragraphs give some idea of the results obtained.

"It can be seen from the yields recorded that a wide variation exists from year to year with the same varieties grown upon the same farms, as well as a great variation in yields on different farms. From a close examination of Table No. 1, it will be observed that the amount of precipitation varies greatly in different years, as well as in the time of year at which it falls. Under such variable conditions, then, it is quite impossible to draw any definite and reliable conclusion until these tests have been continued for a longer period of time. It will be observed from the tables, however, that Turkey wheat leads all other varieties tested for any one year on the different farms, with a yield of 33.9 bushels per acre. This variety also gave the highest average yield on three out of five of the farms upon which it was grown."

Three other varieties—Lofthouse, Gold Coin, and Kofod are close rivals of Turkey wheat, as will be observed from the yields; and are very popular wheats with the dry farmer. They are excellent drouth resistant varieties. It is the writer's opinion, however, that Turkey wheat is destined to become the most popular dry farm wheat of any yet tested, as it becomes better known among the farmers of the state. The two spring varieties of Durum wheat, Black Don 8232 and Pellissier 7785, which are being grown as fall wheats, show great promise of developing into excellent fall varieties. Their drought resistant qualities are superior to most of the others tried."

2. WEIGHT of 100 Kernels.

It has been pointed out that the data giving the weight per 100 kernels is very important, since the heavier the kernel, as a rule, the larger the weight per bushel, and, as has been claimed, the greater the amount of first grade flour that may be obtained.* Wiley** gives the average weight of 100 kernels of wheat as 3.866 grams. Merrill*** and Woods gives the average weight of 100 kernels of Maine grown wheat as being 3.225. We have only this data for the year 1906, but even this shows some interesting results as will be seen by consulting tables Nos. 1 and 1a. The average weight of 100 kernels of the common bread varieties is 3.0417 grams, the lowest weight being 2.2286 for Odessa, and the highest being 4.4859, for Wellman's Fife.

The average weight of 100 kernels of the Durum wheat is 3.7258 grams, the lowest weight being 2.8193 for Yellow Gharnovka 2830, while the highest is 4.5825 for Black Don 8232. This shows distinctly that the Durum wheats weigh more per 100 kernels; the average for the two classes giving .6841 grams in favor of the Durum wheats.

It is a noteworthy fact that this factor seems to vary materially in wheats grown under the different conditions found on our various experimental farms. The average of two determinations of Mahmondi 7792 from the Tooele County farm is 3.5482 grams per 100 kernels while a like average from the San Juan County farm gives 4.2122 grams per 100 kernels, a difference of .6642 grams in favor of that product in San Juan County.

3. Yield of Milling Products.

In tables Nos. 1 and 1a there will also be found the data giving the results obtained on milling the various samples of wheat. A quantity of the wheat, usually 30 pounds, was weighed, soaked and milled. The weight of the various milled products, (flour, bran, and shorts,) was recorded and can be found in the respective columns as flour, bran, and shorts. The column headed

*Bulletin No. 50 Central Experiment Farm, Ottawa, Canada.

**Bulletin No. 13, part 9, Bureau of Chemistry, U. S. Dept. of Agric.

***Maine Agric. Experiment Station, Bulletin 97.

" per cent error," indicates just how closely the work was done. The plus sign indicates a gain while the minus sign indicated a loss in the process of milling.

As pointed out above, the results obtained are not absolute, i. e. a better yield would probably have been obtained in a large flour mill, but the important point to remember is that our results are comparative and indicate the relative value of the various varieties from the point of view of yield of the milling products.

The results show a distinct variation in the yield of milling products obtained from the various varieties and also in the same varieties from the different experimental farms. The variation between the so-called bread varieties of wheat is as high as 10 per cent while the variation between the Durum varieties is as high as 20 per cent. Arranging the common varieties of wheat in the order of their yield of milling products, we have, Gold Coin, Blue Stem, Kofod, Turkey, Winter La Salle, New Zealand, Sonora, Odessa, and Wellman's Fife. Arranging the Durum wheats in the same order we would have, Mahmondi, Yellow Gharnovka, Pellissier, Romnow, and Medeah.

It has been claimed** that the weight per 100 kernels is an index to the yield of first grade flour which may be obtained from the wheat, i. e. the heavier the weight of the kernel the greater the yield of flour. An examination of tables Nos. 1 and 1a will indicate that this is not always the case, at least with us.

4. Moisture of Grain and Milling Products.

The summaried results* obtained by the Bureau of Chemistry, United States Department of Agriculture give the following as the moisture content of the domestic wheat; Maximum 14.53, minmium, 7.11, mean, 10.62.

Judged by this standard it can be seen by consulting tables Nos. 2, and 2a, that all of our varieties have a very low moisture content. None of them approach anywhere near the maximum, the highest being 11.55 per cent for Black Don. All the remaining varieties are below the average given by Wiley. It is note-

*Bulletin No. 13, part 9, Bureau of Chem., U. S. Dept. of Agric.

**Bulletin No. 50, Central Exp. Farm, Ottawa, Canada.

TABLE No. 1. Showing Weight per 100 Kernels and Percentage of Milling Products. (Common Bread Varieties)

Where Grown	No. of Tests	Weight in Grams of 100 Kernels	VARIETY	Percent. Flour	Percent. Bran	Percent. Shorts	Percent. Error
Tooele Co	2		Gold Coin	58.95	33.16	5.24	—2.63
Sevier Co.	2		Gold Coin	56.25	33.46	8.11	—2.13
Juab Co.	1		Gold Coin	61.04	35.09	6.93	+3.06
Iron Co.	1	3.0014	Gold Coin	55.94	38.06	10.86	+4.86
Average				58.04	34.94	7.78	+0.76
Tooele Co.	1		Kofod	58.80	31.95	4.67	—4.56
Juab Co.	1		Kofod	60.01	34.93	2.56	—2.50
Iron Co.	2	3.0381	Kofod	57.10	34.74	7.67	—0.49
Washington Co.	1		Kofod	51.69	37.92	8.43	+1.96
Average				56.90	34.89	5.83	—2.38
Juab Co.	1	2.5636	Turkey	55.00	36.76	5.32	—2.91
Iron Co.	1		Turkey	60.15	21.39	14.62	—3.84
Sevier Co.	2		Turkey	54.94	31.05	12.41	—1.89
Tooele Co.	2		Turkey	54.19	32.32	12.42	—1.05
Washington Co.			Turkey	48.99	29.61	21.58	+0.18
Average				54.65	30.23	13.27	—1.85
Tooele Co.	2		Salzier's	46.10	34.99	16.90	+2.01
San Juan Co.	2	3.3628	Assinobia Fife	51.11	21.04	21.22	—6.63
Average				48.60	28.01	19.06	—4.33
Tooele Co.	2		Wellman's Fife		42.65	14.35	
San Juan Co.	2	4.4859		51.35	31.56	16.35	0.74
Average					37.10	15.35	
Tooele Co.	1		Sonora	57.78	37.02	4.66	+0.53
Washington Co.	1		Sonora	47.61	33.26	18.63	+0.50
Average				52.69	35.14	11.64	+0.52

TABLE No. 1—Continued. Showing Weight per 100 Kernels and Percentage of Milling Products. (Common Bread Varieties)

Where Grown	No. of Tests	Weight in Grams of 100 Kernels	VARIETY	Percent. Flour	Percent. Bran	Percent. Shorts	Percent. Error
Washington Co.	1		Winter La Salle	52.15	38.87	10.01	—1.03
Servier Co.	2		(Lofthouse)	49.73	41.43	7.12	—1.72
Tooele Co	7		(Lofthouse)	56.08	34.47	7.24	+2.20
Iron Co.	6	2.7541	(Lofthouse)	59.95	28.36	10.92	—0.77
San Juan Co.	8	3.4575	(Lofthouse)	53.39	33.01	11.29	—2.31
Average				54.37	35.22	9.31	—1.57
Greenville	21		New Zealand (Irri.)	60.78	32.25	8.64	+1.67
Servier Co.	2		New Zealand (Arid)	51.94	40.24	6.25	—1.01
Washington Co.	1		New Zealand (Arid)	50.30	35.57	15.98	+1.85
Average				51.12	37.90	11.12	+0.34
Tooele Co.	2		Odessa	55.90	34.75	7.77	+1.58
Juab Co.	1		Odessa	49.27	42.74	7.93	—0.06
Iron Co.		2.2286	Odessa	55.44	29.48	12.23	—2.84
Servier Co.	2		Odessa	53.17	37.74	7.83	—1.26
Washington Co.	1		Odessa	46.23	38.67	14.23	—0.87
Average				52.00	36.68	9.99	—1.33
Iron Co.	1		Blue Stem	64.56	23.60	9.67	—2.17
Juab Co.	1		Blue Stem	50.35	44.42	7.59	+2.36
Tooele Co.	1		Blue Stem	56.90	32.10	9.24	—1.76
Average				57.27	33.37	8.83	—0.53
Juab Co.	1		Red Chaff	55.19	35.04	7.14	—2.68
Sevier Co.	1		Red Chaff	48.26	41.07	8.90	—1.77
Tooele Co.	1		Red Chaff	53.61	36.28	8.14	—1.97
Washington Co.	1		Red Chaff	46.16	36.43	16.30	—1.11
Average			Red Chaff	50.80	37.20	10.12	—1.88
Servier Co.	2		Northcoates Amber	53.90	36.33	7.89	+1.88
San Juan Co.	1		Whitington	55.25	35.74	9.60	+0.59
Washington Co.	1		White Club	48.06	38.81	12.95	—0.18
General Average				53.21	35.11	10.91	— .54

TABLE No. 1a. Showing Weight of 100 Kernels and Percentage of Milling Products.

(DURUM VARIETIES.)

Where Grown	No. of Tests	Weight in Grams of 100 Kernels	VARIETY	Percent. Flour	Percent. Bran	Percent. Shorts	Percent. Error
Tooele Co.	2		Richi	49.38	28.33	22.81	+ .52
Washington Co.	1		Nicaragua	46.65	27.40	23.93	—2.02
San Juan Co.	1		Romonow	54.35	34.85	9.72	—1.08
Iron Co.	1	2.8193	Gharnovka 2880	59.49	25.47	13.27	—1.77
San Juan Co.	1	4.5825	Black Don 8232	47.27	29.72	22.92	—0.09
Juab Co.	1		Medeah 7579	48.12	42.35	8.06	—1.47
San Juan Co.	1	3.7952	Medeah 7579	59.70	24.72	22.92	+7.34
Average				53.91	33.53	15.49	+2.93
Juab Co.	1		Adjinni 7580	51.45	37.99	14.56	+4.00
Juab Co.	1		Kahla 7794	45.92	41.25	8.99	—3.84
San Juan Co.	1	3.7537	Kahla 7794	39.99	33.52	25.98	—0.51
Average				42.95	37.38	17.48	—2.19
Juab Co.	1		Pellissier 7785	55.21	35.21	6.35	—3.23
Tooele Co.	2	3.5481	Mohmondi 7792	40.63	32.68	27.08	+0.39
San Juan Co.	2	4.2122		36.97	29.47	33.86	—0.28
Average		3.8802		38.80	31.07	30.47	+0.34
Juab Co.	1		Mohamed ben Bochir 7793	47.53	34.94	12.52	—5.00
Iron Co.	1	2.7809	Mohamed ben Bochir 7793	58.57	30.77	13.02	—1.32
Average				53.05	30.77	13.02	—3.16
General Average				50.23	31.97	17.27	—0.52

worthy that the moisture content of the Durum wheats is higher as a rule than that of the so-called bread varieties. The difference, however, is very small. There is a slightly greater difference in the percentage of moisture in the flour obtained from the two kinds of wheat. This is to be expected inasmuch as the Durum wheats from which the flour was made has a higher moisture content. The moisture of common market wheat flour is given by Wiley as 12.28 per cent. It is seen that flour produced from Utah wheat contains 3.55 less moisture. This is an important item to the consumer. The moisture content of the bran and shorts obtained from the two kinds of wheat is practically the same.

5. The Protein Content of Wheat and Milling Products.

Protein. The crude protein analysis is of interest inasmuch as it gives the total proteids in the grain and in the various milled products. Further than this, it shows the distribution of the nitrogen in the milled products. This data when studied in connection with the other analytic data is of considerable importance, in judging the value of a wheat for milling purposes.

The protein content of domestic wheat is given by Wiley* as, maximum 17.15 per cent, minimum 7.11 per cent, mean 12.23 per cent. Shepard** gives 15.60 per cent as the average protein content of Durum wheats grown in South Dakota. Leach† gives the protein content of wheat as 12.35 per cent. Williams†† gives 12.94 as the average per cent protein of Ohio wheat for four years. The analysis of 22 samples of Blue Stem wheat grown in Washington ‡ gave an average protein content of 11.79 per cent, while the analysis of 7 samples of Turkey Red gave 11.46 per cent.

Shaw § reports the protein content of six samples of the Turkey wheat grown in California, the average of which is 12.97 per cent. Harper and Peters give 12.33 per cent and 11.85 per cent as the

*Bulletin No. 13, part 9, Bureau of Chem., U. S. Dept. of Agric.

**Bulletin No. 92, South Dakota Experiment Station.

†Food Inspection and Analysis.

††Bulletin No. 165, Ohio Experiment Station.

‡The American Miller, Dec. 1, 1907, pp. 978.

§Bulletin No. 185, California Exp. Station.

protein contents of Golden Coin and Turkey wheats respectively, grown in Kentucky.* Judged by these standards, all of our wheats are excellent, the protein content being very high. The average protein contents of our common bread varieties is 16.76 and of our Durum varieties is 17.14, only .38 per cent protein in favor of the Durum varieties of wheat. As would be expected, the variety grown on irrigated land has the lowest protein content: however, when this variety is grown on arid farms its protein content increases. It is noteworthy that **the protein content of Gold Coin is the lowest of any variety grown on the arid farms.** It has already been pointed out by Wiley** that the protein content of spring wheat is higher than that of fall wheat. In connection with this it can also be pointed out that those varieties having the highest protein content are spring varieties.

Before the introduction of macaroni wheats into this country, macaroni was made from the ordinary bread varieties of wheat; but the macaroni was recognized as being of an inferior grade, due, it is claimed,*** to the low protein content. The thought suggests itself that since our common bread varieties have almost as high a protein content as the Durum wheats why could not they be used for the production of macaroni. The department of agronomy reports that the yield of Durum wheat is not up to the standard in this state, but with our ordinary bread varieties having as high a protein content and giving better yields, why should we grow the Durum wheats?

Important variations in the protein content of the flour made from the varieties of wheat grown in Minnesota and Maine and from the same varieties grown in Utah will be discussed below under the chemical composition of the flour.

The average percent of protein in the bran and shorts obtained from the common bread varieties and the macaroni varieties of wheat is practically the same. The protein content of the bran and shorts from the Durum varieties is 19.41 and 18.59, respectively, while that of the bread varieties is 19.46 and 17.66. The difference, it can be seen from these figures, is scarcely no-

*Bulletin No. 113, Kentucky Experiment Station.

**Yearbook Department of Agriculture, 1899, p. 244.

***Bulletin 77, South Dakota Eperiment Station, pp. 41.

TABLE No. 2. Showing Moisture and Protein in Grain ann Milling Products.

(DURUM VARIETIES)

WHERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7
Tooele Co.....	2	Mahmondi 7792	9.76	21.63	19.69	7.76	19.22	17.49	8.65	23.04	20.97	8.67	20.09	18.29
San Juan Co....	2	Mahm. 7792 ..	10.38	17.61	16.04	9.46	17.83	16.24	9.56	19.56	17.80	7.35	16.44	15.48
Iron Co.	1	Mahm. 7792 ...	11.66	19.15	17.44	10.58	18.86	17.15	9.72	22.04	20.06	9.37	19.57	17.84
Average.....			10.60	19.46	17.72	9.27	18.64	16.96	9.31	21.55	19.61	8.46	18.70	17.20
Juab Co.	1	Kahla 7194	8.26	18.91	17.21	6.26	14.26	12.99	10.04	19.40	17.67	9.53	17.98	16.35
Iron Co.	1	Kahla 7194	9.06	21.11	19.21	10.50	21.67	19.76	9.73	21.61	19.72	9.71	20.13	18.35
San Juan Co....	1	Kahla 7194	11.46	18.25	16.64	10.31	16.84	15.35	10.00	19.61	17.84	10.16	15.01	13.68
Average.....			9.59	19.42	17.68	9.02	17.59	16.03	9.92	20.21	18.41	9.80	17.71	16.12
Juab Co.	1	Mohamed ben-	6.75	18.00	16.41	10.37	17.13	15.61	13.23	21.24	19.32	8.74	17.42	15.84
Sevier Co.	1	Bachir 7793..	.....	.....	.....	.....	1846	16.81	.....	18.37	16.70	.....	17.14	15.61
Iron Co.	1	"	10.09	19.45	17.72	10.68	18.65	16.98	9.43	23.14	21.09	9.41	23.07	21.03
Average.....			8.42	18.73	17.06	10.52	18.08	16.47	11.33	20.92	19.03	9.08	19.21	17.49
Tooele Co.....	2	Richi	8.21	17.93	16.33	9.55	16.92	15.38	7.51	18.51	16.84	7.32	17.46	15.90
Juab Co.	1	Medeah	7.18	18.26	16.64	9.10	17.31	15.73	9.21	19.56	17.84	8.67	17.42	15.84
San Juan Co....	2	Medeah	11.51	17.57	15.98	9.18	17.37	15.81	6.42	18.48	16.84	8.50	17.94	16.32
Average.....			9.34	17.91	16.31	9.14	17.34	15.77	7.81	19.02	17.33	8.62	17.68	16.08

TABLE No. 2. Showing Moisture and Protein of Grain and Milling Products.

(DURUM VARIETIES)

WHERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7
Juab Co.	1	Adjini 7580 ...	6.34	18.51	16.87	11.07	17.46	15.90	9.22	20.37	18.52	9.05	18.27	16.64
Juab Co.	1	Pellissier 7785.	6.13	17.55	15.96	9.87	16.56	15.10	10.68	18.29	16.64	9.26	17.12	15.56
Washington Co.	1	Nicaragua	8.28	22.83	20.80	7.99	21.61	19.66	8.73	26.02	23.71	8.11	23.35	21.26
Iron Co.	1	Yel. Gharnovka	9.60	19.17	17.44	10.03	17.86	16.24	10.05	24.22	22.05	10.09	19.65	17.89
San Juan Co....	1	Black Don 2830	11.55	17.35	15.78	10.33	15.21	13.85	10.04	24.56	22.40	10.11	15.72	14.30
Tooele Co.....	1	Romnow	9.56	19.31	17.61	8.02	17.33	16.24	8.97	21.57	19.66	6.51	18.97	17.27
San Juan Co....	2	Romnow	10.01	17.07	15.53	9.03	15.73	14.30	8.87	20.07	18.29	6.22	20.23	18.41
Average.....			9.78	18.19	16.57	8.52	16.78	15.27	8.92	20.82	18.97	6.37	19.60	17.84
General Average.....			8.89	18.82	17.14	9.57	17.64	16.06	9.41	21.32	19.41	8.75	18.59	16.93

TABLE No. 2a. Showing Moisture and Protein of Grain and Milling Products.

(COMMON BREAD VARIETIES)

WHERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5,7
Tooele Co.....	1	Whitington . . .	9.67	19.07	17.38	7.75	17.91	16.30	15.21	23.97	21.83	8.33	19.86	18.10
San Juan Co....	1	Whitington . . .	8.35	16.29	14.82	8.29	14.89	13.56	7.89	19.17	17.44	6.91	.....	.....
Average.....			9.01	17.68	16.10	8.02	16.40	14.93	11.55	21.57	19.63	7.62	19.86	18.10
Washington Co.	2	White Club ...	7.34	22.15	20.17	7.85	18.82	17.15	10.59	26.01	23.71	8.49	23.15	21.09
Tooele Co.....	2	Red Chaff	8.79	17.30	15.75	8.49	15.40	14.04	7.47	19.80	18.01	7.48	17.80	16.21
Juab Co.	1	Red Chaff.....	4.99	17.46	15.90	8.39	15.58	14.19	9.05	21.36	19.43	10.11	17.25	15.73
Sevier Co.....	2	Red Chaff.....	7.11	19.09	17.38	9.06	18.29	16.64	9.20	20.62	18.78	8.93	19.47	17.72
Washington Co.	1	Red Chaff.....	8.27	19.81	18.06	7.82	19.98	18.18	8.40	22.88	20.86	7.07	20.32	18.52
Average.....			7.29	18.41	16.77	8.44	17.31	15.76	8.53	21.16	19.27	8.40	18.71	17.04
Sevier Co.....	2	Northco. Amber	8.41	17.52	15.93	7.92	14.84	13.50	9.52	19.51	17.75	9.11	18.79	17.09
Sevier Co.....	2	Winter la Salle.	8.44	19.40	17.70	11.58	15.08	13.73	12.22	19.65	17.89	12.25	17.76	16.18
Tooele Co.....	6	(Lofthouse) ...	7.72	17.17	15.64	8.94	17.44	15.88	8.79	21.85	19.90	6.57	19.18	17.47
Iron Co.	6	(Lofthouse) ...	9.66	19.62	17.86	9.62	17.93	16.33	9.78	23.15	21.09	9.89	20.32	18.51
San Juan Co....	9	(Lofthouse) ...	9.47	16.27	14.92	10.16	15.45	14.07	9.24	20.26	18.47	9.09	17.46	15.89
Washington Co.	1	(Lofthouse) ...	8.28	19.44	17.72	4.50	18.39	16.75	7.39	22.09	20.12	7.20	22.24	20.29
Average.....			8.71	18.38	16.65	8.96	16.86	15.35	9.48	21.40	19.49	9.00	19.39	17.67

TABLE No. 2a. Showing Moisture aad Protein of Grain and Milling Products.
(COMMON BREAD VARIETIES)

HERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Prrtein NX6,25	Protein NX5.7
Sevier Co.....	2	New Zealand ..	9.53	17.09	15.59	9.71	14.85	13.54	8.79	19.75	18.01	9.30	19.23	17.49
Washington Co.	1	(Arid)	8.26	21.22	19.35	4.14	17.80	16.24	7.59	24.02	21.90	7.42	23.05	20.97
Greenville	23	(Irrig.) ...	9.12	15.63	14.25	8.56	13.34	12.54	8.56	20.82	18.99	7.73	16.56	15.09
Average.....		.....	8.89	19.25	17.47	6.92	16.32	14.89	8.19	21.38	19.95	8.36	21.14	19.23
Tooele Co.....	3	Odessa	8.80	17.36	15.82	10.27	16.50	15.02	10.19	21.13	19.24	8.01	20.49	18.67
Juab Co.	1	Odessa	7.44	17.81	16.24	10.58	15.06	13.73	9.88	19.12	17.38	8.29	17.96	16.35
Sevier Co.....	2	Odessa	9.11	18.69	17.04	10.69	16.58	15.10	11.63	22.99	20.94	7.95	20.21	18.40
Washington Co.	1	Odessa	8.56	18.77	17.10	8.41	17.52	15.96	7.77	22.25	20.29	7.57	21.88	19.95
Average	7	.....	8.48	18.16	16.55	9.99	16.41	14.95	9.87	21.37	19.46	7.95	20.13	18.34
Tooele Co.....	2	Gold Coin	8.06	15.40	14.02	9.46	13.63	12.42	8.06	18.52	16.87	8.08	17.51	15.95
Juab Co.	1	(Forty Fold).	7.17	15.80	14.36	10.61	13.90	12.65	10.07	20.21	18.41	8.66	18.01	16.41
Iron Co.	1	(Forty Fold).	9.61	17.93	16.30	9.84	14.42	13.11	10.11	23.05	21.26	10.54	19.50	17.78
Sevier Co.....	2	(Forty Fold).	8.25	17.36	15.78	10.14	14.59	13.27	9.26	19.94	18.15	8.67	17.93	16.33
Average	6	.....	8.27	16.62	15.11	10.01	14.13	12.86	9.37	20.43	18.67	8.99	18.24	16.62
Tooele Co.....	2	Salzier's Assin-	8.60	20.36	18.55	8.91	19.85	18.06	9.27	21.42	19.49	7.69	20.20	18.41
San Juan Co....	2	obia Fife.....10.11		17.91	16.30	9.01	17.38	15.81	8.32	19.49	17.75	10.51	17.55	15.98
Average.....		.....	9.35	19.13	17.42	8.96	18.61	16.93	8.79	20.45	18.62	9.10	18.87	17.19

TABLE No. 2a. Showing Moisture and Protein of Grain and Milling Products.

(COMMON BREAD VARIETIES)

WHERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6;25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7
Sevier Co.....	2	Turkey	8.63	17.70	16.12	9.16	15.49	14.10	9.26	19.62	17.86	8.80	17.06	15.53
Tooele Co.....	2	Turkey	8.05	17.17	15.64	8.12	15.67	14.25	9.03	18.93	17.23	8.49	16.61	15.13
Washington Co.	1	Turkey	8.26	19.70	17.95	4.62	21.76	19.83	7.37	25.75	23.37	6.78	19.96	18.18
Iron Co.	2	Turkey	8.98	18.10	16.47	10.96	16.83	15.33	8.12	21.03	19.17	14.32	18.96	17.27
Juab Co.	1	Turkey	7.44	17.69	16.13	9.44	15.85	14.42	8.91	18.98	17.27	8.64	16.01	14.59
Average.....			8.27	18.07	16.46	8.46	17.12	15.59	8.54	20.86	18.98	9.41	17.72	16.14
Tooele Co.....	2	Sonora	8.13	17.71	16.12	9.43	16.33	14.87	9.23	20.01	18.24	9.40	17.95	16.33
Washington Co.	1	Sonora	8.38	18.06	16.47	7.66	18.88	17.21	7.67	19.18	17.49	7.45	18.91	17.21
Average.....			8.25	17.88	16.29	8.54	17.60	16.04	8.45	19.59	17.86	8.42	18.43	16.77
Tooele Co.....	2	Wellman's Fife	8.16	20.75	18.89	9.87	19.84	18.06	9.95	24.12	21.97	9.02	22.11	20.14
San Juan Co....	2	Wellman's Fife	10.04	17.59	16.01	10.15	16.16	14.73	9.01	20.16	18.35	8.73	18.01	16.42
Average.....			9.10	19.17	17.45	10.01	18.00	16.39	9.48	22.14	20.16	8.87	20.06	18.28
Iron Co.	1	Kofod.....	8.15	18.99	17.27	10.01	18.14	16.53	7.64	23.50	21.43	8.86	18.82	17.15
Tooele Co.....	1	Kofod.....	7.48	13.70	12.48	11.23	13.22	12.02	7.90	17.59	16.01	9.85	15.38	14.02
Juab Co.	1	Kofod.....	7.81	18.80	17.10	8.33	15.08	13.73	9.61	21.97	20.00	6.88	18.71	17.04
Average.....			7.81	17.16	15.61	9.86	15.48	14.09	8.38	21.02	19.14	8.53	17.64	16.07

TABLE No. 2a. Showing Moisture and Protein of Grain and Milling Products.

(COMMON BREAD VARIETIES)

WHERE GROWN	No. of Tests	VARIETY	GRAIN			FLOUR			BRAN			SHORTS		
			H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7	H_2O	Protein NX6.25	Protein NX5.7
Juab Co.	1	Blue Stem	7.12	17.14	15.61	9.60	15.41	14.02	7.06	19.38	17.67	8.72	17.41	15.84
Tooele Co.	1	Blue Stem	8.11	19.36	17.61	8.13	16.69	15.21	7.51	21.66	19.72	7.00	19.04	17.32
Iron Co.	1	Blue Stem	9.71	19.89	18.12	10.54	18.87	17.15	9.17	23.36	21.26	9.28	21.40	19.49
Average			8.31	18.80	17.11	9.42	16.99	15.46	7.91	21.47	19.55	8.33	19.28	17.55
General Average			8.46	18.44	16.76	8.84	16.79	15.29	9.25	21.33	19.46	8.71	19.39	17.66

ticeable. Shepard* calls attention to the fact that the protein content of bran and shorts produced from Durum wheat grown in South Dakota is higher than that of the bran and shorts produced from the ordinary bread varieties, hence the former would be of more value as a stock food. It is important to note that the bran and shorts produced from the ordinary bread varieties of Utah grown wheats are equally as nutritious as the bran and shorts produced from the Durum varieties, as far as can be judged from chemical analysis.

6. Chemical Composition of the Flour

a. The folowing terms are defined:

Gluten. The gluten consists of gliadin and glutenin together with a small quantity of other proteids and is that substance which is left after the flour has been washed free from starch.

Gliadin. The gliadin is that material which under the influence of water, forms a sticky medium which binds together the particles of flour, rendering the dough and gluten tough and coherent.

Glutenin. The glutenin is that proteid which remains after the extraction, by means of 70 per cent alcohol, of the gliadin from the gluten. According to Osborne and Voorhees,** "The glutenin imparts solidity to the gluten, evidently by forming a nucleus to which the gliadin adheres, and from which it is consequently not washed away with water."

b. Value of Analytic Data.

There has been considerable work done in judging the bread making qualities of a flour from a chemical analysis of the same. Unfortunately, sufficient analytic data is not available so that one can form an absolutely correct opinion regarding the value of flour for breadmaking but valuable information can be obtained by a study of the chemical characteristics. Considering these facts it is to be regretted that breadmaking tests were not

*Bulletin No. 77 South Dakota Experiment Station, pp. 44.

**Osborne and Voorhees Conn. Sta. Rpt., 1892, pp. 145.

carried on in connection with the chemical work. This has been impossible in the past as the wheat has not been scrubbed before milling and for this reason would have made a dark bread.

However there are investigators who claim that, to a certain extent, the bread making qualities of flour can be judged from a chemical analysis. The quality of gluten can be told from a chemical analysis of the same. H. A. Guss* states that the ratio of the gliadin to the glutenin is a good index to the elastic qualities of the glutenin. He states further, "The ratio of the gliadin to the glutenin has been used tentatively as an index of the glutenin quality. So far as the writer has been enabled to have this index checked by actual baking tests on the flour produced, it was found that the elastic quality of the gluten was improved in proportion as the gliadin to the glutenin increased, and as yet no limit has been found beyond which increase of gliadin ratio rendered the gluten inelastic or sticky." T. B. Guthree** gives similar standards, differing only from other writers in the limit laid down. This difference is undoubtedly due to a difference in the solvent used in obtaining the gliadin. Snyder,*** in his work, has found that, while not absolute, there are certain ratios which produce better bread than others. He usually found the ratio of 65 per cent of gliadin to 35 per cent of glutenin the best ratio. M. Fleurent**** lays down the following rules for judging the baking qualities of a flour: "Whatever be the quantity of gluten in a flour, that one will furnish the better developed loaf and consequently the more readily digested, in which the gluten approaches the following composition: Glutenin, 25 per cent; gliadin, 75 per cent; or three parts gliadin to one part glutenin.

"Bread made from flour containing 20 per cent glutenin to 80 per cent gliadin ferments well but becomes flat and compact in baking. For such a flour, the amount of water usually employed for working, is always too great, and a larger portion of the flour must be taken to make the dough."

*Jour. Amer. Chem. Soc. 22, p. 265.

**Agr. Gaz. N. S. Wales, 1896, 583-590, 1898, 365-366.

***Minn. Sta. Bull. 63, 51; No. 85, 194.

****Comptes Rendus, Nov. 9, 1896, p. 755.

"When the glutin contains 34 per cent glutenin to 66 per cent gliadin the dough fails to rise, both in the ferment action and in the oven, the bread remains compact and indigestible, the flour working only with great difficulty."

"Taking as a type bread made from the flour whose gluten has the composition of 75 per cent gliadin to 25 per cent glutenin, the bread from flour whose gluten contents varies as little as 2 per cent from these proportions shows differences which an expert can readily distinguish."

LeClerc* emphasizes the necessity of producing wheat having a high protein content and says that in some localities, wheat is bought on the basis of chemical analysis itself. He calls attention to the necessity of cultivating those varieties of wheat having the two desired characteristics, high gluten content and large yield.

The ash determinations** are of value in determining the grade of flour or in other words, they are a check on the milling. The more bran present in the flour the greater the ash. The ash of plants varies*** in different localities, especially is this true of the arid conditions, for we have found that the ash of plants grown in Utah is high as compared with those grown on land not so rich in mineral constituents. This fact must be taken into consideration in comparing our results with those of other investigators.

Acidity of a flour is usually an index to the maturity of the wheat, besides showing whether or not heating or fermentation has taken place in the flour or grain.

c. Protein, Dry and Wet Gluten.

The protein, the moist gluten and dry gluten, content of flour tent of flour are given by Wiley**** in the following table:

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*Year Book Dept. of Agriculture, 1906.

**Minn. Sta. Bull. 85, 191; Zeit. Anal. Chem. 37, p. 87.

***Arkansas Station Bulletin No. 42, pp. 70-72.

****Bulletin No. 13. part 9, Bu. of Chem. U. S. Dept. of Agric.

	No. of Anal.	Protein N 5.7	M. Gluten	D. Gluten
Patent Wheat Flour	40	9.62	25.97	9.99
Common Market Wheat Flour.	19	9.28	24.55	9.21
Bakers' and Family Flour....	14	11.20	34.70	13.07

Judged by this standard, it can be readily seen that the flour produced from all varieties of wheat grown in Utah, both the common bread varieties and the Durum varieties, are exceptionally high in protein. The moist and dry gluten of all varieties are very high, far above the average as given by Wiley. Again, the mois' and dry gluten of the Durum varieties are slightly higher than that of the bread varieties. The Northwestern Milling Company's standard for moist gluten is 38.75 per cent. According to this standard, there is only one sample of flour falling below the standard, Gold Coin. A study of table IV brings out the relations between wheat grown in Utah and the same varieties grown in other states. A study of the table also brings out better than any other process can, the superiority of Utah grown wheats.

A Comparison Between Flour From Utah Grown Wheat and That Made From Wheats Grown in the Middle West and in Maine.

Locality	Variety	Protein	M Gluten	D. Gluten	Ratio
*Western,	Fife.....	13.75	26.66	10.95	2.43:1
*Maine,	Fife.....	13.03	28.65	11.31	2.53:1
Utah,	Fife.....	15.99	45.70	16.39	2.75:1
*Western,	Blue Stem...	11.51	24.07	9.99	2.42:1
*Maine,	Blue Stem...	11.69	24.60	11.32	2.44:1
Utah,	Blue Stem...	15.52	45.59	17.39	2.62:1

d. Ratio of Wet and Dry Gluten.

The column headed "Ratio of wet to dry gluten" gives some interesting data inasmuch as it gives the water holding capacity of flour. In other words, it tells whether or not the flour will make a light loaf. The loaf becomes lighter as the ratio increases. It will be noticed that this number is nearly a constant for all our varieties, there being very slight variation from the average, 2.65:1. Whitington has the highest ratio, 3.02:1, while Kahla, has the lowest, 2.42:1.

*Bulletin No. 97, Maine Agric. Eexperiment Station, p. 159.

The theory* has been advanced that a good baking flour should have 55 to 65 per cent of its protein in the form of gliadin. An excess of gliadin produces a flour which is soft and sticky while a flour which is deficient in gliadin does not have the power to expand sufficient to make a light loaf. The glutenin is the material to which the gliadin adheres, thus preventing it from becoming soft and sticky.

e. Gliadin (N x 5 7).

The following will show the gliadin content and the proportion of protein in the form of gliadin as found by Shepard:**

	Per cent Gliadin of total protein	Per cent Gliadin
Blue Stem	66.8	8.28
Black Don	49.4	7.78

Snyder*** reports the gliadin content of wheat from the various parts of the world, from which it can be seen that the gliadin content varies from 3.9 per cent to 7.26 per cent while the per cent protein in the form of gliadin varies from 42.1 per cent to 73.1 per cent—a variation of over 30 per cent. Blue Stem is reported as having a gliadin content of 7.84 per cent, while its protein content in the form of gliadin is 66.7 per cent.

Shutt** found that the gliadin contents of Canadian flours varies from 4.33 per cent to 4.90 per cent while the per cent of protein in the form of gliadin varies from 38.1 per cent to 45 per cent. Minnesota****flours vary in their gliadin content from 4.73 to 5.58 per cent while the per cent of protein the form of gliadin varies from 41.1 per cent to 53.9 per cent. Snyder‡ seems to think that it is more a question of total gliadin than ratio of gliadin to glutenin which determines the value of a flour.

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*Minn. Station Bulletin No. 54, p. 42

*Bulletin No. 67, U. S. Department. Agr. Office Exp. Sta., p. 22.

**Bulletin No. 92, South Dakota Agric. Col. & Exp. Sta.

***Chemistry of Plant and Animal Life, p. 277.

‡Bulletin No. 50, Central Experimental Farms.

****Bulletin No. 90, Minn. Exp. Sta.

Table No. 3. Showing Chemical Composition of Flour. (Common Bread Varieties).

WHERE GROWN	No. of Tests	VARIETY	Per Cent Protein NX6.25	Per Cent Protein NX5.7	Per Cent Wet Gluten	Per Cent Dry Gluten	Ratio of Wet to Dry Gluten	Gliadin NX5.7	Glutenin	Per Cent Protein NX5.7 in form of Gliadin	Per Cent Acidity	Ash
Sevier Co.	2	Winter La Salle.....	15.10	13.77	39.86	15.17	2.62:1	8.09	5.68	58.7	.20	0.93
Iron Co.	6	(Lofthouse)	17.93	16.35	48.41	18.85	2.57:1	9.66	6.69	59.1	.16	0.69
San Juan Co.....	9	(Lofthouse)	15.67	13.62	41.20	15.62	2.64:1	7.68	5.97	56.4	.14	....
Tooele Co.	5	(Lofthouse)	16.68	15.22	45.71	17.87	2.58:1	7.93	7.29	53.2	.23	....
Washington Co.	1	(Lofthouse)	18.39	16.77	39.38	14.26	2.76:1	7.53	7.32	50.8	...	....
Average.....			16.75	15.14	42.91	16.35	2.63:1	8.18	6.59	55.6	.18	....
Juab Co.	1	Turkey	15.85	14.46	45.25	15.54	2.91:1	8.72	5.74	60.3	.13	....
Sevier Co.	2	Turkey	15.49	14.13	42.62	17.50	2.43:1	7.58	6.55	53.6	.22	....
Tooele Co.	2	Turkey	15.28	15.47	44.63	16.48	2.71:1	7.69	7.78	49.7	.23	....
Iron Co.	3	Turkey	17.27	15.75	43.54	16.58	2.62:1	8.92	6.83	56.6	.17	0.43
Washington Co.	1	Turkey	21.76	19.84	45.66	17.12	2.66:1	8.55	11.29	43.1	.40	....
Average.....			17.13	15.93	44.34	16.64	2.66:1	8.29	7.64	52.0	.23	....
Tooele Co.	1	Kofod	13.22	12.07	39.34	14.58	2.69:1	6.84	5.23	56.6	...	....
Washington Co.	1	Kofod	15.35	14.00	.....	.....	.....	8.26	5.74	59.0	.23	....
Iron Co.	1	Kofod	16.40	14.94	48.04	18.44	2.61:1	.....	.....	.....	.13	1.09
Average.....			14.99	13.67	43.69	16.51	2.64:1	7.55	5.48	57.8	.18	....
Juab Co.	1	Blue Stem	15.41	14.05	38.51	16.91	2.28:1	.....	.....	.....	.16	....
Tooele Co.	1	Blue Stem	16.69	15.22	48.47	19.15	2.53:1	8.04	7.16	52.8	.29	....
Iron Co.	1	Blue Stem	18.97	17.30	49.80	17.91	2.78:1	10.49	6.81	60.6	.15	0.83
Average.....			17.02	15.52	45.59	17.39	2.62:1	9.27	6.98	56.7	.20	....

Table No. 3. Showing Chemical Composition of Flour. (Common Bread Varieties)

WHERE GROWN	No. of Tests	VARIETY	Per Cent Protein NX6.25	Per Cent Protein NX5.7	Per Cent Wet Gluten	Per Cent Dry Gluten	Ratio of Wet to Dry Gluten	Gliadin NX5.7	Glutenin	Per Cent Protein NX5.7 in form of Gliadin	Per Cent Acidity	Ash
Tooele Co.	2	Gold Coin	13.63	12.59	.....	.....	.....	7.98	4.61	63.3	.13	....
Juab Co.	1	(Forty Fold)	13.90	12.68	36.66	13.77	2.66:1	7.87	4.81	62.0	...	....
Sevier Co.	2	(Forty Fold)	14.59	13.31	.....	.....	.....	7.98	5.35	59.9	.28	....
Iron Co.	1	(Forty Fold)	14.42	13.15	36.30	13.39	2.71:1	8.49	4.46	64.5	.11	.59
Average			14.13	12.93	36.48	13.58	2.69:1	8.08	4.81	62.5	.17	....
Tooele Co.	2	Sonora	16.34	15.01	.....	.....	.....	9.23	5.78	61.5	.25	....
Washington Co.	1	Sonora	18.88	17.22	41.70	15.85	2.63:1	7.41	9.81	43.0	.30	....
Average			17.61	16.11	.....	.....	.....	8.32	7.79	51.6	.27	....
Tooele Co.	1	Whitington	17.91	16.34	54.34	20.08	2.70:1	9.80	6.54	60.0	.19	....
San Juan Co.	1	Whitington	14.89	13.58	51.25	14.80	3.46:1	7.70	5.88	56.6	.15	....
Average			16.40	14.96	52.79	17.44	3.02:1	8.75	6.21	58.5	.17	....
Greenville	23	New Zealand (Irrig.)	13.34	12.16	40.17	13.40	2.87:1	6.96	5.20	57.2	.15	....
Washington Co.	1	New Zealand (Arid)	17.80	16.24	47.56	19.97	2.38:1	8.44	7.80	51.9	.26	....
Sevier Co.	2	New Zealand (Arid)	14.85	13.54	45.39	15.00	3.02:1	6.95	6.59	51.3	.19	....
Average			16.32	14.89	46.47	17.48	2.70	7.69	7.19	51.6	.22	....
Tooele Co.	1	Salzier's Assinobia Fife.	21.30	19.44	53.99	19.72	2.73:1	10.72	9.72	55.4	.25	....
San Juan Co.	2	Salzier's Assinobia Fife.	17.38	15.87	47.00	17.33	2.71:1	7.89	7.98	49.8	.27	1.54
Average			19.34	17.65	50.49	18.52	2.72:1	9.30	8.35	52.7	.26	....

Table No. 3 Showing Chemical Composition of Flour. (Common Bread Varieties)

WHERE GROWN	No. of Tests	VARIETY	Per Cent Protein NX6.25	Per Cent Protein NX5.7	Per Cent Wet Gluten	Per Cent Dry Gluten	Ratio of Wet to Dry Gluten	Gliadin NX5.7	Glutenin	Per Cent Protein NX5.7 in form of Gliadin	Per Cent Acidity	Ash
Tooele Co.	1	Wellman's Fife	18.91	17.25	51.20	17.66	2.89:1	10.09	7.16	58.5	.28	....
San Juan Co.....	2	Wellman's Fife	16.16	14.74	40.20	15.13	2.66:1	8.35	6.39	56.6	.20	1.00
Average.....			17.53	15.99	45.70	16.39	2.79:1	9.22	6.77	57.6	.24	....
Tooele Co.	2	Odessa	15.87	14.48	42.01	16.18	2.59:1	7.55	6.93	52.1	.10	....
Juab Co.	1	Odessa	15.10	13.77	42.08	18.25	2.31:1	.....	.....	.....	.16	....
Sevier Co.	2	Odessa.....	16.58	15.16	45.67	17.99	2.54:1	8.09	7.03	53.5	.23	....
Washington Co.	1	Odessa.....	17.52	15.98	43.84	18.38	2.38:1	8.78	7.20	54.9	.30	....
Iron Co.	1	Odessa.....	17.76	16.20	43.12	16.78	2.57:1	9.52	6.68	58.8	.13	0.89
Average.....			16.56	15.11	43.34	17.51	2.47:1	8.48	6.96	54.8	.18	....
Washington Co.	2	White Club	18.82	17.16	51.35	19.45	2.64	9.73	7.44	56.6	...	....
Sevier Co.	2	Northcoates' Amber	14.85	13.55	37.51	13.38	2.80:1	8.03	5.52	59.2	.23	....
General Average.....			16.73	15.28	16.65	16.65	2.69:1	8.53	6.75	55.94	.21	.89

Table No. 3a. Showing Chemical Composition of Flour. (Durum Varieties)

WHERE GROWN	No. of Tests	VARIETY	Per Cent Protein NX6.25	Per Cent Protein NX5.7	Per Cent Wet Gluten	Per Cent Dry Gluten	Ratio of Wet to Dry Gluten	Gliadin NX5.7	Glutenin	Per Cent Protein NX5.7 in form of Gliadin	Per Cent Acidity	Ash
Juab Co.	1	Medeah 7579	17.32	15.80	.....	.....	.....	9.18	6.62	58.1	.21	....
San Juan Co.	2	Medeah 7579	17.37	15.84	46.53	17.66	.....	8.27	7.57	52.2	.31	1.57
Average			17.34	15.82	.....	.....	2.63:1	8.72	7.10	55.1	.26	....
Juab Co.	1	Kahla 7794	14.20	12.95	.....	.....	.....	8.78	4.17	67.8	.26	....
Iron Co.	1	Kahla 7794	21.67	19.76	.....	.....	.....	10.66	9.10	53.9	.44	....
San Juan Co.	1	Kahla 7794	16.84	15.36	44.45	18.31	2.42:1	8.85	6.51	57.6	.27	0.91
Average			17.57	16.02	.....	.....	.....	9.43	6.59	58.8	.32	....
Juab Co.	1	Mohamed ben	17.13	15.63	44.40	17.28	2:57:1	8.04	7.59	51.4	.24	....
San Juan Co.	1	Bachir 7793	18.46	16.84	.....	.....	.....	8.27	8.57	49.1	.38	....
Iron Co.	1	"	18.65	17.01	.....	.....	.....	10.44	6.55	61.3	.15	.60
Average			18.08	16.49	.....	.....	.....	8.92	7.57	54.1	.29	....
Juab Co.	1	Pellisier 7785	16.56	15.10	45.70	15.95	2.86:1	8.61	6.49	57.0	.25	....
Juab Co.	1	Adjini	17.46	15.92	.....	.....	.....	9.80	6.12	61.5	.23	....
Washington Co.	1	Nicaragua	21.61	19.71	.....	.....	.....	9.99	9.72	50.7	...	....
San Juan Co.	1	Romanow	17.05	15.55	.....	.....	.....	8.21	7.34	52.8	.18	....

Table No. 3a. Showing Chemical Composition of Flour. (Macaroni Varieties)

WHERE GROWN	No. of Tests	VARIETY	Per Cent Protein NX6.25	Per Cent Protein NX5.7	Per Cent Wet Gluten	Per Cent Dry Gluten	Ratio of Wet to Dry Gluten	Gliadin NX5.7	Glutenin	Per Cent Protein NX5.7 in form of Gliadin	Per Cent Acidity	Ash
Iron Co.	1	Yellow Gharnovka 2830.	17.86	16.29	.....	.....	.....	9.41	6.88	57.7	.13	.89
San Juan Co.....	1	Black Don	15.21	13.88	.....	.....	.....	8.84	5.04	64.9	.23	.82
Tooele Co.	2	Richi	16.92	15.41	49.42	18.60	2.65:1	8.55	6.86	55.5	.31	....
San Juan Co.....	2	Mahmondi 7792	17.99	15.95	42.15	18.19	2.32:1	8.60	7.35	53.9	.37	1.00
Tooele Co.	2	Mahmondi 7792	19.56	17.84	55.44	22.52	2.46:1	10.05	7.79	56.3	...	1.05
Iron Co.	1	Mahmondi 7792	18.86	17.20	49.98	18.01	2.77:1	10.26	6.94	59.6	...	0.73
Average.....		.....	18.80	16.99	49.19	19.57	2.51:1	9.64	7.35	56.7	...	.92
General Average.....			17.68	16.11	46.69	17.89	2.61:1	9.10	7.01	56.80	.25	0.946

Recently Shepard* has found that although the protein content of the flour made from the Durum wheats grown in South Dakota, is higher than that of the soft varieties, the gliadin content of the former is usually lower than that of the latter. A glance at Table No. 3 will show that this is not the case with Utah grown wheats, both the protein content and the gliadin content of the flour made from the Durum wheats is slightly higher than that of the soft varieties. It can be seen that the difference is .83 per cent in case of the protein content and about .6 per cent in case of the gliadin.

Compared with these results it is seen that all of our varieties of Utah wheat are exceptionally well provided with gliadin. No variety has as low a gliadin content as the highest of any of the above. The average gliadin content for all the varieties of wheat is 8.88 per cent while that of the Durum varieties is 9.21 per cent.

f. Protein in Form of Gliadin.

The column headed "Percentage of protein N x 5.7 in form of gliadin" contains some important data. Compared with the above analysis it will be seen that all of our wheats produce flour which is above the average in this factor. The average of the common bread varieties is 55.94 per cent while the average for the Durum varieties is 56.80 per cent. It will be seen that while Blue Stem grown in Utah contains a higher per cent of gliadin than the same variety grown in Canada or Minnesota, yet the proportion of protein in the form of gliadin in Blue Stem wheat here is 10 per cent less than that reported by Snyder or Shutt. However, the percentage of protein in form of gliadin in the flour made from Blue Stem wheat, 56.7 per cent, still places it in the class having from 55 to 65 per cent of its protein content in the form of gliadin. Recently Snyder** seems to have modified his views on this subject and now believes that is more a question of total amount of gliadin present than the relative proportion of gliadin to glutenin which determines largely the value of a flour for bread making. In view of this it is well to call attention to the

*Bulletin No. 99, South Dakota Exp. Sta.

**Bulletin No. 50, Central Exp. Farms, Ottawa, Canada, p. 18.

fact that although the relative proportion of gliadin to glutenin in Utah wheats compares favorably with the average, yet the gliadin content in all is exceptionally high, the average being higher than the highest of any reported analysis. Furthermore, the ratio of gliadin to glutenin would undoubtedly have been greater had the milling been done more closely since Fleurent has shown that the center of the kernel contains more glutenin.

g. Acidity.

In the analysis of flour from some Canadian grains, Shutt shows that the acidity varies from .15 per cent to .41 per cent. Snyder says that the acidity of normal flour usually ranges from 0.09 per cent to 0.15 per cent while in old and musty flour it may run as high as 0.5 per cent. According to the standard set by Snyder, all of our flours contain a relative high percentage of acidity, most of them having a higher per cent than the maximum set by Snyder. We have not proceeded far enough with our investigations to explain with absolute accuracy just why this condition exists.

C. CONCLUSION.

The data contained in this publication is by no means conclusive. The problem as to which is the best varieties of grain for our state is yet unsettled but it is hoped that the data presented will be of some help to the farmers of the state in determining the variety they desire to grow. The work here reported is rather a report of progress than a final report. Much important data, however, is presented for consideration.

The following is a brief summary of the most important results obtained:

1. No single variety now possesses, combined, the desired characteristics of yield, protein content, flour yield, weight per bushel, and the most desirable miling qualities. However, sufficient evidence is presented to indicate those varieties which it will be most profitable to use for selection in order to obtain the desired results.

2. A low moisture content is characteristic of Utah grains.

3. The protein content of Utah grains is very high, being much above the average.

4. The protein content of the wheat grown on irrigated land is lower than that of wheat grown on the arid farms.

5. The protein content of Gold Coin is the lowest of any variety grown on arid farms.

6. When the variety grown on irrigated land is transferred to arid land its protein content increases.

7. The theory that the heavier the weight per 100 kernels the greater the yield of flour obtained does not receive any support from our work.

8. The statement that spring varieties of wheat have a higher per cent of protein is confirmed by our results.

9. The protein content of the common bread varieties is nearly equal to that of the Durum varieties, the difference being only .5 per cent.

10. The Durum wheats are heavier, kernel for kernel, than the bread varieties.

11. There are noticeable variations in the yield, milling, and chemical characteristics of the same varieties of wheat grown on the various arid farms of the State.

12. The moist and dry gluten content of Utah wheats is very high.

13. The bran and shorts produced from the common bread varieties of wheat are fully as nutritious as the bran and shorts produced from the hard varieties of wheat.

14. If the gluten content determines the value of Durum wheats for the making of macaroni, the common bread varieties grown in Utah should be just as valuable for this purpose.

15. The gliadin content of Durum wheats is slightly higher than that of the soft varieties.

How much remains to be done? The work must be continued with our better varieties. The work herein reported is by no

means conclusive in character. The work must extend over a period of years in order to get data upon which to base a reliable opinion. However, some very important data is presented at this time for the consideration of the farmer. It may help to bring about that desirable day when Utah will be known as the home of some one definite variety of wheat characterized by a high protein content, good yielding capacity, and desirable milling and chemical characteristics.

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